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Short communication

Reducing pollution at five critical points of shale gas production: Strategies and institutional responses

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HIGHLIGHTS

- Shale gas development involves releases of unnecessary pollutants.
- Major sources of unnecessary pollutants can be identified.
- For major pollutant sources, strategies can be developed to reduce releases of contaminants.
- Alternative strategies can offer firms and governments ways to reduce pollutant releases.

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ABSTRACT

While the public and governments debate the advisability of engaging in shale gas production, the United States has proceeded to develop its resources with an accompanying remarkable increase in natural gas production. The development of shale gas has not been without problems, and some countries have decided that shale gas production should not proceed until more is known about the accompanying health issues and environmental damages. From experiences in the United States, careful consideration of five critical points relating to shale gas production can form the basis for developing strategies for reducing discharges of pollutants: (1) casing and cementing, (2) handling wastewater, (3) venting and flaring, (4) equipment with air emissions, and (5) seismic events. For each strategy, institutional responses to markedly reduce the risks of harm to people and the environment are identified. These responses offer state and local governments ideas for enabling shale gas resources to be developed without sacrificing public health and environmental quality.

1. Introduction

Considerable public opposition exists to the deployment of hydraulic fracturing technologies used to recover unconventional oil and gas reserves (Clarke et al., 2015). In the United States, the petroleum industry has been successful in overcoming the opposition in most areas of the country so that the country is a major producer of shale gas. At the same time, some U.S. municipal governments and a few state governments have banned shale gas development (Nolon and Gavin, 2013). In Europe, the opposition to shale gas development is stronger (Upham et al., 2015). While there are a number of reasons for public opposition, the main focus is on people's health and the environment. The public is not convinced that introductions of toxic chemicals into their communities and releases of harmful emissions into the air are safe (Rawlins, 2014). Unfortunate mishaps have contributed to the public's concerns (Healy, 2013).

Governments, regulators, and business firms are aware of the public's concerns and have taken many efforts to address them and to minimize pollution (Wiseman, 2014). However, there are different opinions on how governments should address these concerns (Sovacool, 2014). Some feel that given the world's thirst for energy, we need to tap this energy source (Melikoglu, 2014). Another viewpoint is that using natural gas can be part of a stepwise transition toward the adoption of more sustainable materials and sources of energy (McFarland, 2012). Others feel that the world should be transitioning to renewable energy (Abas et al., 2015). Research suggests that cheap gas may displace renewables in countries under pressure to ensure energy supplies (Aguirre and Ibikunle, 2014; Kerr, 2010).

As the world continues to extract more shale gas, the real question is whether governments are doing enough to prevent damages, both to current and future populations. A significant body of research suggests that too many pollutants are being released from shale gas development (Eaton, 2013; Soeder et al.,

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2014; Wang et al., 2014; Werner et al., 2015). Yet the experiences of early adopters disclose five critical points during shale gas development for which regulatory controls can be employed to minimize environmental and health risks: (1) casing and cementing, (2) handling wastewater, (3) venting and flaring, (4) equipment with air emissions, and (5) seismic events. The five critical points were identified from reports of contamination, health maladies, and anticipated degradation associated with shale gas development and the feasibility of instituting responses that would alleviate some of the damages, as noted in the next sections of the paper.

With the identification of these critical points, governments can develop strategies to deal with the use of hazardous chemicals in hydraulic fracturing and the release of harmful pollutants. For each strategy, ideas and specialized regulatory provisions are enumerated to provide energy firms and governments examples of how to structure operations to offer greater protection for the health of nearby residents and to maintain the quality of air and water resources. These institutional responses enable governments to establish safeguards that would protect people and the environment from egregious pollution that may accompany shale gas development.

2. Enumerating five critical points

A wide range of issues and problems have been associated with the development of America's shale gas resources. Highlighting five critical points identifies prominent sources of pollutants that can be reduced by adopting strategies implemented through institutional responses.

2.1. Casing and cementing

A major concern has been deleterious material leaking from shale gas wells, and many of these problems are associated with faulty casing and cementing. A study from Pennsylvania found that 3.3% of violations involved casing and cementing (Considine et al., 2013). Many persons with water wells in proximity to shale gas wells have complained about contaminated water from fracturing fluids (Brantley et al., 2014). Research from the United States shows methane contamination of aquifers (Osborn et al., 2011; Vengosh et al., 2013). One study showed the concentration of methane in drinking water was related to the distance to a shale gas well and that distance was the dominant statistical factor in these concentrations (Jackson et al., 2013).

Since shale gas in the United States is generally located 1500–2500 m underground, layers of rock strata prevent leakage of contaminants into an aquifer. This suggests that contamination of groundwater should not be a problem unless the wellbore is faulty. Fugitive gas contamination problems are related to poor casing and cementing (Darrah et al., 2014). Research indicates gas migration as occurring after the conclusion of cementing jobs during the transition from slurry to solid cement (Soeder et al., 2014). In addition, faulty casings or cementing of wells can allow gases to migrate to drinking water supplies (Davies et al., 2014). This leads to a conclusion that greater oversight of wellbore integrity involving casing and cementing requirements can reduce contamination problems (Osborn et al., 2011; Jackson, 2014).

2.2. Handling wastewater

The public is rightfully concerned about water pollution from fracturing fluids, flowback, and produced water. Some feel that U.S. state enforcement efforts are not very robust, violators are rarely penalized, and penalties are so weak that drilling firms find it cheaper to pay occasional penalties rather than comply with the law (Sumi, 2012). Because fluids used to fracture wells generally contain toxic substances, and the fluids exiting a well may contain additional toxic materials from the rock strata, these liquids must be handled carefully (Vengosh et al., 2014; Vidic et al., 2013; Werner et al., 2015). Vehicular accidents and faulty storage structures may result in the release of toxic materials (Vinciguerra et al., 2015). Given the potent concentrations of selected toxic chemicals, a small spill or leak can have pronounced affects.

Although difficult to calculate, spills and releases of toxic substances associated with oil and gas wells are thought to be between 0.4 and 12.2 spills per 100 wells drilled (U.S. EPA, 2015a). One study suggests that about 3.4% of wells received notices of violations for well construction problems (Brantley et al., 2014). This suggests that efforts to reduce accidents and contain spills are important.

Related to these contamination events is the secrecy of chemical compounds used in hydraulic fracturing. Under U.S. state law, firms can decline to specifically identify any toxic compound that they feel is a trade secret (Centner, 2013; Hall, 2013). The U.S. EPA (2015b) estimates that 11% of all ingredient records were designated as confidential business information, and other research found considerable nondisclosure of all compounds used in fracturing wells (Konschnik and Dayalu, 2016). This creates a situation in which persons may not realize their health maladies are related to a pollutant release from shale gas development. Given the pollutant releases, spills, and accidents that have accompanied shale gas development in the United States, drilling firms may need to make greater investments in suitable precautionary measures to avoid accidents and mishaps. Simultaneously, governments can do more to address damages from contamination events.

2.3. Venting and flaring

Major air pollutants accompanying shale gas extraction are often released from the venting and flaring of methane and other gases at individual wells. These emissions generally consist of numerous pollutants including cancer-causing benzene (Witter et al., 2008). The releases are also related to the development of ozone (Werner et al., 2015). Gases are vented or flared because the costs of collecting them are prohibitive. The U.S. Energy Information Service estimates that more than 288,743 million cubic feet of gas were vented and flared from oil and gas wells in 2014 (U.S. Energy Information Administration, 2014). Global efforts to reduce gas flaring and venting through the evaluation of alternatives show significant opportunities for greenhouse gas emission reductions (Johnson and Coderre, 2012).

In the United States, new federal emissions standards to limit some releases of gases from shale gas wells were introduced in 2012 (U.S. EPA, 2012). The rules prescribe requirements for a separator to recover gas from flowback and route it to a beneficial use (U.S. EPA, 2014b). If it is not put to a useful purpose, the gas must be combusted (U.S. EPA, 2014b). These rules help minimize vented gas during a well completion and reduce air emissions. However, they only apply to new gas wells and some activities of refractured wells. Refractured wells that are not modified may continue to emit air pollutants (U.S. CFR, 2015, §§ 60.5365, 60.5375).

Moreover, wells producing oil, including some wells that produce both oil and gas, are exempted (U.S. EPA, 2012). It is estimated that one-half of new oil wells co-produce natural gas that may be flared or vented (U.S. EPA, 2014c). Excessive air emissions from venting and flaring remain a problem suggesting that governments need to find ways to be more effective in curtailing these pollutants.